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KINNIER, J.

John W. Kinnier

DRAG REDUCTION ON SPHERICAL BODIES
DUE TO CERTAIN ADDITIVES IN WATER.

Thesis
K47

U.S. Naval Postgraduate School
Monterey, California

Dray Red

FORM 100-10

$$\text{Drop Velocity} = \left(\frac{\text{Weight of Drop}}{\text{Resistance in Drag Force}} \right)^{1/2}$$

4. Drop Velocity

Fluid	Drop Size μ	Drop Size μ	Drop Size μ	Drop Size μ	Drop Size μ
0.0% J2P2 Coat II	-	-	-	2.0(1)	-
0.5% J2P2 Coat II	-	-	31.5(15)	33.5(2)	-
1.5% J2P2 Coat II	-	27.0(5)	38.5(17)	40.0(11)	-
1.25% J2P2 Coat II	-	-	27.0(3)	31.5(15)	-
1.25% J2P2 Coat II	-	-	23.0(5)	27.0(10)	-
1.125% J2P2 Coat II	-	-	-	21.0(10)	21.0
1.75% Polym 301	20.0(1)	-	-	-	-
1.50% Polym 301	15.5(4)	25.0(7)	14.0(6)	-	1.0
1.25% Polym 301	12.5(5)	-	-	-	1.5

NOTES:

1. The numbers in parentheses show the number of observations used to determine the results.
2. In the J2P2 Coat II solutions, sugar was added to the glycerol to facilitate pouring into solution.

5. Accuracy of Results: The results presented here were obtained by using the simple arithmetic mean of the total number of observations. No attempt was made to determine standard deviations, probable accuracy, etc. The reason for a given set of observations there was little deviation, and it is felt that conservative estimates of the accuracy of velocity measurements is based on the fact that five or more observations were used for $\pm 4\%$.

(To check the apparatus, and to see how close the average velocity of the drops would correspond to the actual velocity of a given size drop in air, the following average measured velocity for three drops (size 3.0 μm or 10.0 μm or 12.5 μm) were used, whereas the calculated velocity using $V = (2gh)^{1/2}$ was 1.00 μm/sec.

6. General Discussion: A question that is yet unanswered is the reproducibility of results from one solution to another. From the data presented, it is evident that the drag coefficient measurements obtained from the same fluid, the drag coefficient varied between batches by up to 100 percent. Further experimental work would be required to resolve whether this variation is inherent in the measurement of the drag coefficient.

Since the amount of drag coefficient is large in the measurement of the drag coefficient, there are some possibilities that the results of the drag coefficient

1. The first part of the report is a general introduction to the subject of the study. It discusses the importance of the study and the objectives of the research.

2. The second part of the report is a detailed description of the methodology used in the study. It includes information about the sample, the data collection methods, and the statistical analysis.

3. The third part of the report is a discussion of the results of the study. It compares the findings with the previous research and discusses the implications of the study.

4. The fourth part of the report is a conclusion and a list of references. The conclusion summarizes the main findings of the study, and the references list the sources used in the research.

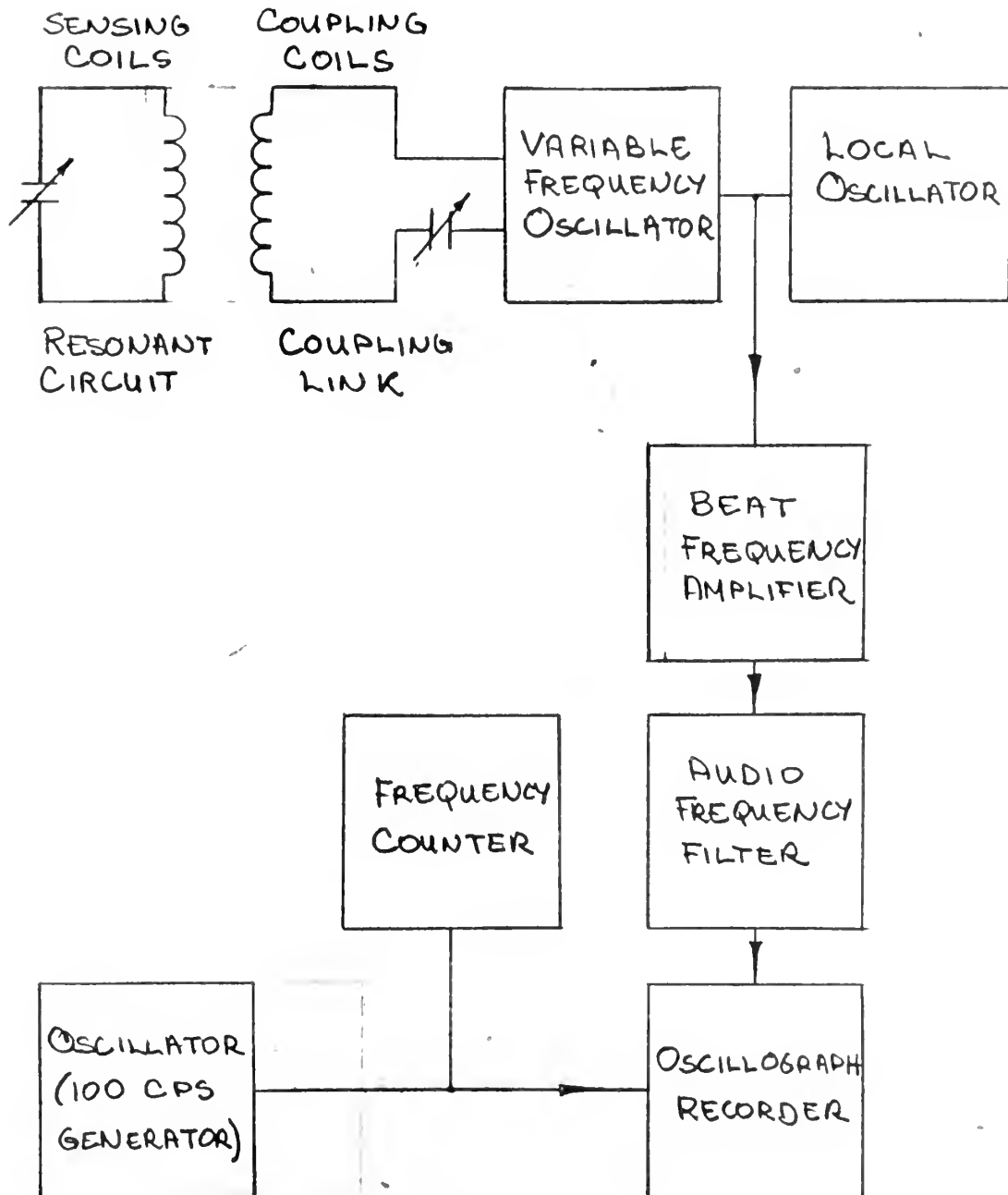
5. The fifth part of the report is a list of appendices. These include additional data, tables, and figures that are not included in the main text of the report.

The purpose of this report is to provide a comprehensive overview of the study and its findings. It is intended for use by researchers and students who are interested in the subject of the study. The report is organized into five main sections: Introduction, Methodology, Results, Conclusion, and References. Each section provides a detailed description of the study and its findings.

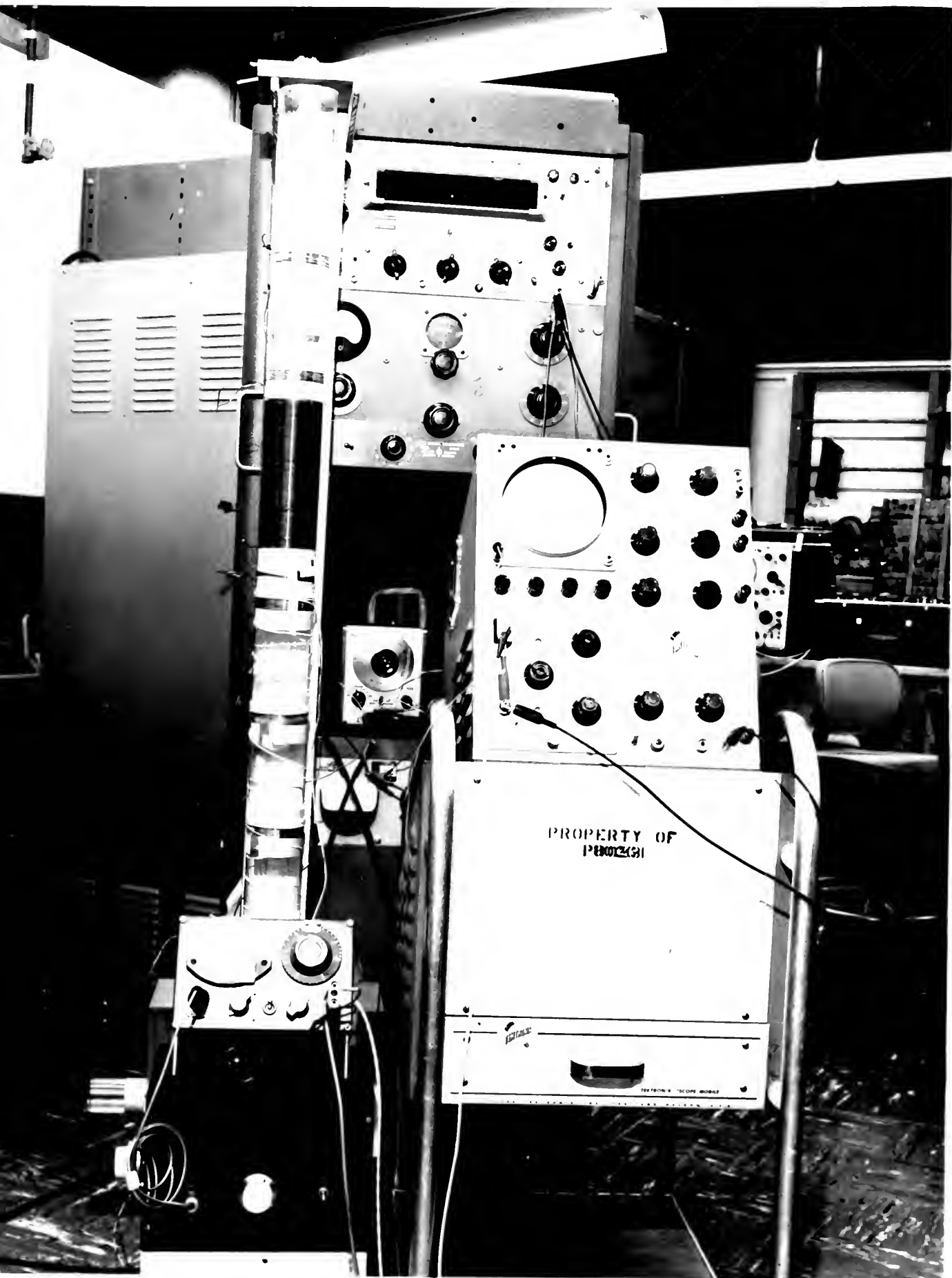
The study was conducted using a quantitative research design. Data was collected from a sample of 100 participants. The data was analyzed using statistical software. The results of the study are presented in the Results section of the report.

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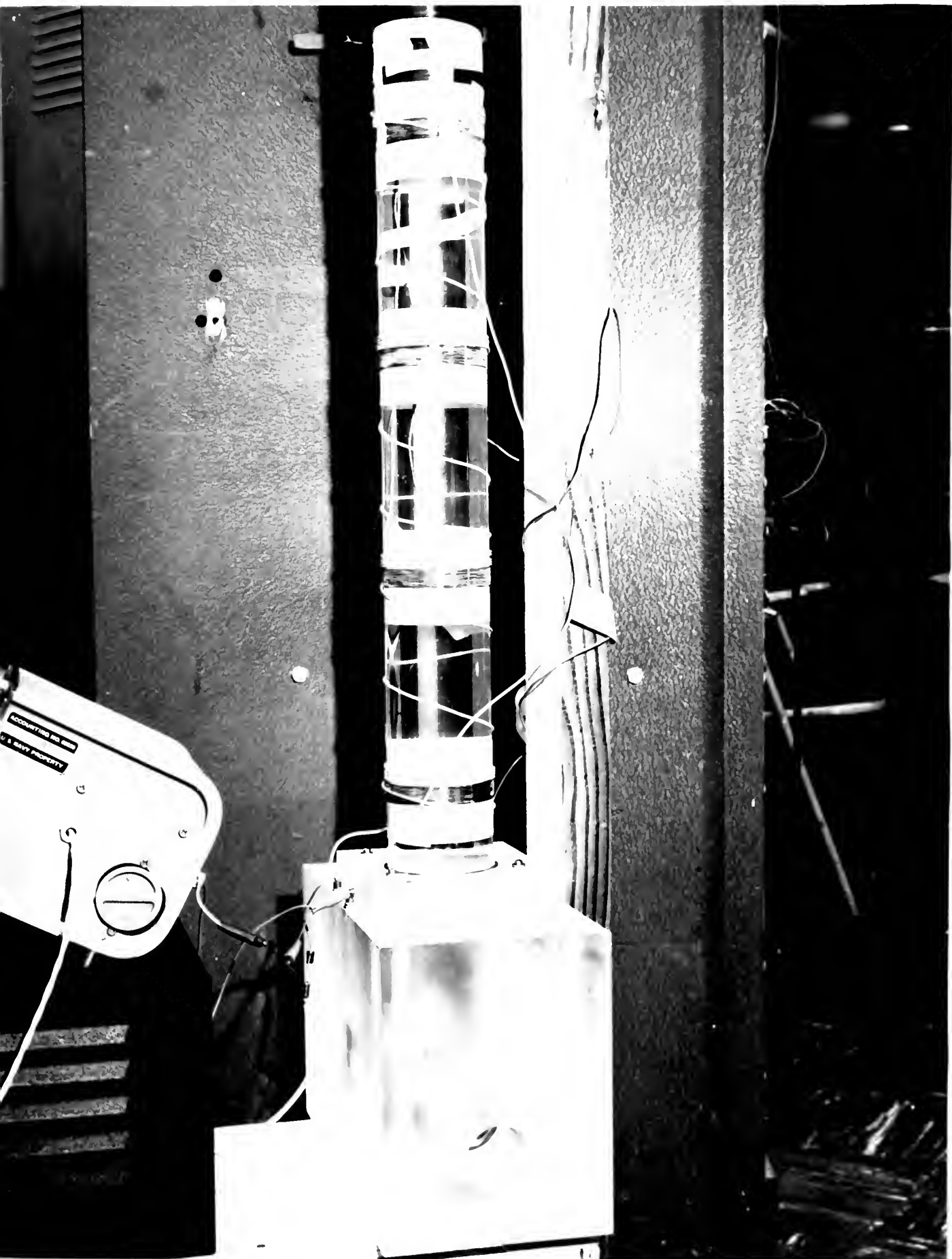
BLOCK DIAGRAM OF EXPERIMENTAL SET-UP



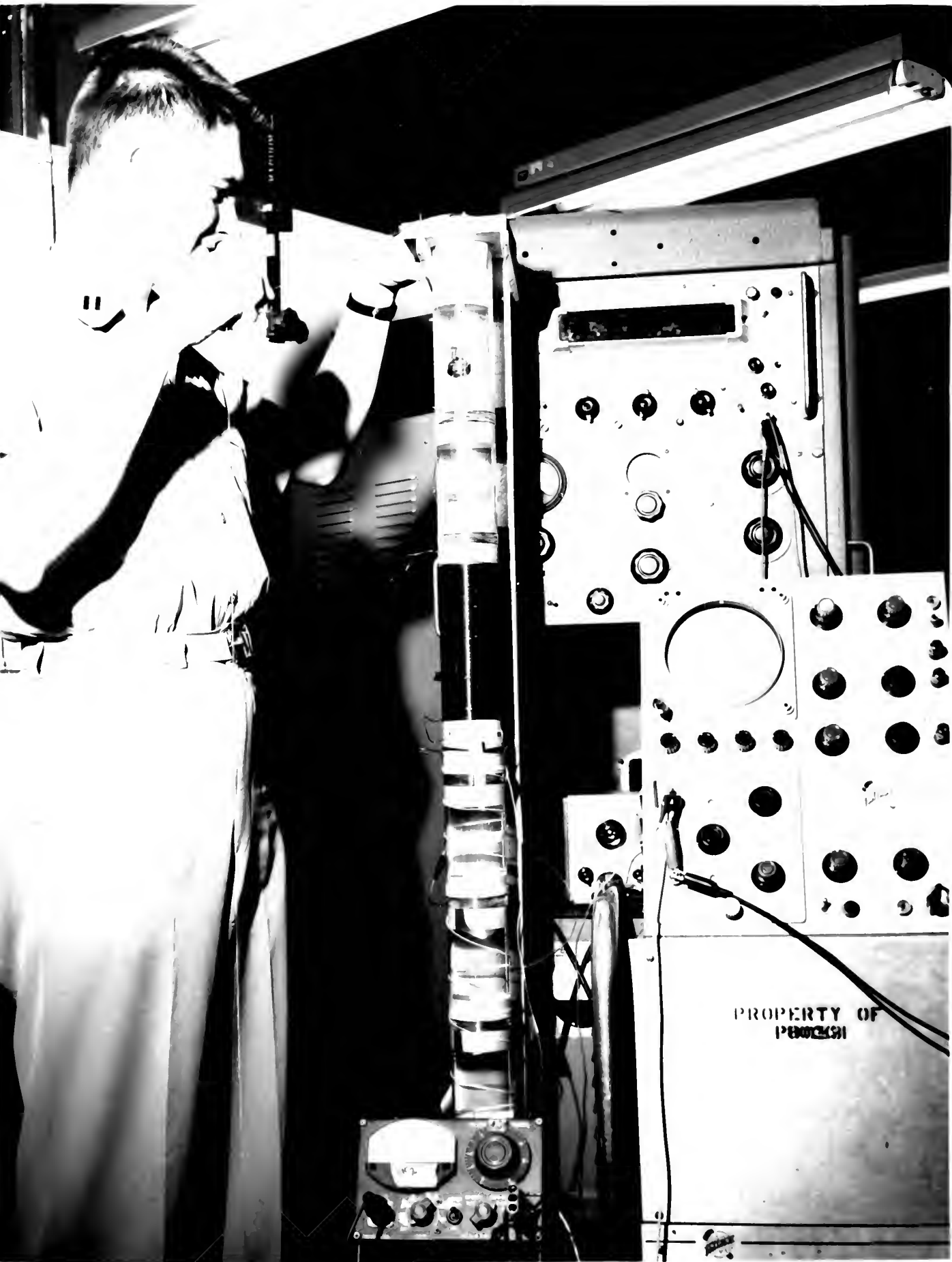
DESCRIPTION OF EQUIPMENT



Department of Defense



Dedication of Forming Dies



DERIVATION OF FORMULAS USED

Symbols

W - Weight of sphere

g - Acceleration due to gravity

B - Buoyant force on sphere

F - Net force on sphere = $W - B$

v - Velocity

k - Drag constant of proportionality
 $= \frac{1}{2} \rho A C_D$

C_D - Coefficient of drag

A - Cross-sectional area of sphere

ρ - Density of fluid

x - Distance of fall

(All units in ft-lb-sec system)

[From $F = ma$]

$$W - B - kv^2 = ma = \frac{W}{g} \frac{dv}{dt}$$

$$v = \frac{dx}{dt} \Rightarrow dt = \frac{dx}{v}$$

$$(F - kv^2) dx = \frac{W}{g} v dv$$

$$\text{Thus } x = \frac{W}{g} \int \frac{v dv}{F - kv^2}$$

$$\text{or } x = \frac{-W}{2gk} \ln(v^2 - \frac{F}{k}) + C \text{ (constant of integration)}$$

$$\text{Setting } v=0 \text{ when } x=0 \Rightarrow C = \frac{W}{2gk} \ln(-\frac{F}{k})$$

$$\therefore x = \frac{W}{2gk} \left[\ln(-\frac{F}{k}) - \ln(v^2 - \frac{F}{k}) \right]$$

$$x = \frac{W}{2gk} \left[\ln \frac{-F/k}{v^2 - F/k} \right] \Rightarrow e^{\frac{2gk}{W}x} = \frac{-F/k}{v^2 - F/k}$$

Solving for v:

$$\rightarrow v = \left[\frac{F}{k} (1 - e^{-\frac{2gkx}{W}}) \right]^{\frac{1}{2}}$$

Note: Terminal Velocity = $\sqrt{F/k}$

A Conservative Approximation for Drag Reduction

(Assumes terminal velocity has been reached in both the fluid tested and water.)

$$\text{Drag Force} = F = \frac{1}{2} A \rho C_D v^2$$

$$\text{Drag Reduction} = \frac{\text{Drag in H}_2\text{O} - \text{Drag in Fluid}}{\text{Drag in H}_2\text{O}}$$

$$\cong \frac{C_{D_{H_2O}} - C_{D_{\text{fluid}}}}{C_{D_{H_2O}}}$$

$$\cong \frac{\frac{F}{\frac{1}{2} A \rho v_{H_2O}^2} - \frac{F}{\frac{1}{2} A \rho v_{\text{fluid}}^2}}{\frac{F}{\frac{1}{2} A \rho v_{H_2O}^2}}$$

$$\cong 1 - \left(\frac{v_{H_2O}}{v_{\text{fluid}}} \right)^2$$

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Drag reduction on spherical bodies due t



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